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Indian Standard

PERMANENT POLYMER COATING MATERIALS (SOLDER-RESIST) FOR USE IN THE MANUFACTURE OF PRINTED CIRCUITS — SPECIFICATION

UDC 621·315·616 96 [678·7] : 621·3·049·75

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April 1993 **Price Group 4**

Printed Circuits Sectional Committee, LTD 17

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Printed Circuits Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

This specification is based on IEC Pub 249-3-3 (1991) 'Base materials for printed circuits — Part 3 : Special materials used in connection with printed circuits—Specification No. 3 : Permanent polymer coating materials (solder-resist) for use in the fabrication of printed boards', issued by the International Electrotechnical Commission (IEC).

Indian Standard

PERMANENT POLYMER COATING MATERIALS (SOLDER-RESIST) FOR USE IN THE MANUFACTURE OF PRINTED CIRCUITS — SPECIFICATION

1 SCOPE

1.1 This standard specifies requirements and tests for solder resist material, as manufactured and as used, for a solder-resist system which comprises the material, the application process and a printed board.

2 REFERENCES

2.1 The following Indian Standards are necessary adjuncts to this Standard:

IS No.	*Title*
1885 (Part 6) : 1978	Electrotechnical vocabulary : Part 6 Printed circuits (*first revision*)
4486 : 1967	Recommended methods for the determination of the permittivity and dielectric dissipation factor of electrical insulating materials at power, audio and radio frequencies including metre wavelengths
5921 (Part 1) : 1983	Metal-clad base materials for printed circuits for use in electronic and telecommunication equipment : Part 1 General requirements and tests
7405 (Part 1) : 1983	Specification for printed wiring boards : Part 1 General requirements and methods of test (*first revision*)
9000 (Part 3) : 1977	Basic environmental testing procedures for electronic and electrical items : Part 3 Dry heat test
9000 (Part 4) : 1979	Basic environmental testing procedures for electronic and electrical items : Part 4 Damp heat (steady state)
9000 (Part 6) : 1978	Basic environmental testing procedures for electronic and electrical items : Part 6 Composite temperature/humidity cyclic test
9000 (Part 18) : 1981	Basic environmental testing procedures for electronic and electrical items : Part 18 Solderability test

3 TERMINOLOGY

3.1 In addition to the terms and definitions given in IS 1885 (Part 6) : 1978, the following shall be applicable for the purpose of this standard.

3.1.1 *Solder-Resist Bleeding* — The flowing of a screen-printed solder-resist coating beyond the areas of the image as applied.

3.1.2 *Solder-Resist Residue* — Incompletely removed photo-definable solder-resist materials on areas intended for soldering, usually caused by inadequate development or rinsing.

3.1.3 *Solder-Resist Blisters* — Air, moisture or entrapped volatiles which rise under the resist either during curing or soldering operations.

3.1.4 *Solder-Resist Hydraulic Stability* — The ability of a solder-resist to withstand and exposure to elevated temperature and humidity without an irreversible change of state.

3.1.5 *Solder-Resist Skipping* — Phenomenon seen when surface areas adjacent to between conductors are not coated with solder-resist.

3.1.6 *Solder Webbing* — Solder adhering to the surface of a solder-resist after the soldering operation.

3.1.7 *Solder-Resist Wrinkling* — The formation of ridges, creases, or furrows in solder-resist.

3.1.8 *Solder-Resist Cold Flow* — A deformation that may occur in dry film solder-resist during storage. The film flows out at the ends of the rolls resulting in non-uniform thickness.

4 DESIGNATION

4.1 Types

Solder-resist for the uses considered in this specification may be either of two types, as specified by the purchaser:

Type A — For Screen Printed Patterns

Type B — For Photo Definable Patterns

a) Wet film

b) Dry film

4.2 Classes

Class 1 — Materials typically used in consumer products

Class 2 — Materials typically used in general industrial applications

Class 3 — Materials typically used in life support equipment

5 MARKING

5.1 Marking of Containers

Each container shall be legibly and durably marked with at least the following:

a) The designating code of the material, including type, class, flammability, etc;

b) The manufacturer's lot or batch number;

c) The manufacturer's name or recognized trade-mark;

d) The specified storage temperature, or range of temperature, and final date of use;

e) Any applicable safety instructions or waring notices, such as flammability, flash point, or toxicity;

f) Mixing instructions where appropriate (for example for two-part materials); and

g) The quantity in the container.

5.1.1 Each container may also be marked with the BIS Certification Mark.

6 SOLDER-RESIST MATERIAL PROPERTIES EVALUATION

6.1 Mold Growth — (Under consideration)

6.2 Flammability

Coatings off cured solder-resist applied in the thickness and by a process, both as recommended by the supplier, shall not reduce the flammability class of a base material, when tested in accordance with **7.2.3** of IS 5921 (Part 1) : 1983.

6.2.1 *Test Specimen*

Four coated and four uncoated specimens 13 ± 1 mm wide and 125 ± 5 mm long shall be evaluated.

6.3 Hydrolytic Stability/Ageing

Coatings of cured solder-resist shall withstand the conditions established in Table 1 without an irreversible change of state when tested as specified in Test.

Table 1 Stability Conditions
(*Clause* 6.3)

Sl No.	Class	Conditions		
		°C	% RH	Days
i)	1	40 ± 2	93^{+2}_{-3}	4
ii)	2	85 ± 2	93^{+2}_{-3}	10
iii)	3	85 ± 2	93 + 2	56

6.3.1 *Test Specimen*

Three copper-clad base material test specimens 100 ± 10 mm x 100 ± 10 mm with solder-resist coating applied and cured, as recommended by the manufacturer, shall be evaluated.

6.4 Permittivity and Dissipation Factor Damp Heat and Recovery (Optional)

The permittivity and dissipation factor shall be determined after damp heat and recovery at 1 MHz in accordance with IS 9000 (Part 4) : 1979 and **5.4** of IS 5921 (Part 1) : 1983.

Additional measurements at frequencies other than 1 MHz, and relevant requirements, may be agreed upon between the purchaser and the supplier. The values determined at each frequency shall be reported, together with the test method used.

6.4.1 *Test Specimen*

The test specimen shall be determined in accordance with IS 4486 : 1967. Four test specimens, with the solder-resist coating applied and cured, as recommended by the manufacturer, shall be evaluated for each frequency and test method.

6.5 Corrosion at the Edge (Optional)

The edge corrosion of brass foils shall not be less than A/B degree at the positive pole and not worse than 1.4 degree at the negative pole when tested in accordance with **5.8** of IS 5921 (Part 1) : 1983.

6.5.1 *Test Specimen*

Three specimens, the size as specified in **5.8** of IS 5921 (Part 1) : 1983, with the solder-resist coating applied and cured as recommended by the manufacturer, shall be evaluated. The cured solder-resist shall have a thickness of 0.05 ± 0.01 mm and be applied to a glass substrate with a minimum thickness of 3 mm.

7 SOLDER-RESIST SYSTEM EVALUATION

7.0 The tests in this clause provide a combined evaluation of the polymer coating, the application of the polymer, and the substrates.

The solder-resist system evaluation shall be used to express the properties as tested with an actual printed board(s). The solder-resist system evaluation may also be used by the printed board manufacturer or user to select and qualify a solder-resist material.

7.1 Test Specimen — Base material.

7.1.1 The test specimen may be a production printed board or a standard test board as agreed between the supplier and the user.

Surface preparation of test specimen should be according to manufacturer's recommendations.

7.2 Mechanical Tests

7.2.1 *Mechinability*

The solder-resist coating applied over the base material shall not crack or tear when subjected to dilling, sawing, routing or punching that is normally associated with the printed board manufacturing process. This property shall be determined by visual inspection without magnification.

7.2.1.1 *Test Specimen*

Three test specimens, 100 + 10 mm x 100 + 10 mm, with the solder- resist coating applied and cured as recommended by the manufacturer, shall be evaluated. The same test specimen may be used for the applicable mechanical tests in **7.2.1** through **7.2.4**.

7.2.2 *Adhesion Test, Tape Method*

The maximum percentage of cured solder-resist lifted from the surface of the base material and conductor materials shall be in accordance with Table 2. The tape and tape method used shall be in accordance with **12.1.1** of IS 7405 (Part 1) : 1983. Six + 1 cuts should be made at spacing of 2 mm in each direction of the 90° lattice pattern uniform non-interrupted surface.

7.2.2.1 *Test specimen*

Three test specimens, approximately 15 x 15 mm and three composite test patterns, where applicable, with the solder-resist coating applied and cured as recommended by the manufacturer, shall be evaluated for each surface to be tested.

7.2.3 *Dimensional*

The cured solder-resist shall cover all required surfaces and shall meet the thickness requirements of the relevant specification when measured at the centre of the coated conductor with an accuracy of +0.002 mm. The minimum thickness values in Table 3 have been found to be acceptable requirements.

Table 3 Resist Thickness

Class 1	Visual coverage
Class 2	0.013 mm minimum
Class 3	0.025 mm minimum

7.2.3.1 *Test specimen*

Three test specimens, with the solder-resist coating applied and cured as recommended lay the manufacturer, shall be evaluated (*see* **7.2.1.1**).

7.2.4 *Hardness*

The hardness of the cured solder-resist shall be determined by the Pencil Test in accordance with Test Method 2 of Annex A. The solder-resist manufacturer shall report the limits of hardness that can be expected when the polymer coating is properly applied and cured. When agreed upon between customer and vendor, specific requirements regarding hardness shall be met.

7.2.4.1 *Test specimen*

Three test specimens, with the solder-resist coating

Table 2 Adhesion Requirements

(*Clause* 7.2.2)

Sl No.	Conditioning Prior to Tape Test	Test Specimen and Material	Allowed Classification*		
			Class 1	Class 2	Class 3
(1)	(2)	(3)	(4)		
i)	Solder float [13.2.3 of IS 7405 (Part 1) : 1983]	Uniform, non-interrupted Surface of non-melting metal			
		Bare copper	1	0	0
		Cold or nickel	1	0	0
ii)	Solder float [13.2.3 of IS 7405 (Part 1) : 1983]	Base material	0	0	0
iii)	Cross-cutting (No solder float)	Uniform, non-interrupted Surface of melting metal			
		Tin or tin lead	1	1	0

*Classifications:

0 — The edges of the cuts are completely smooth, more of the squares of the lattice is deleted.

1 — Detachment of small flakes of the coating at the inter-sections of the cuts. A cross out area not distinctly greater than 5% is affected.

applied and cured as recommended by the manufacturer, shall be evaluated (*see* **7.2.1.1**).

7.2.5 *Thermal Shock*

The solder-resist coated test specimen shall be preconditioned in accordance with **13.1.1** of IS 7405 (Part 1) : 1983 for a minimum of one hour and a maximum of four hours. The flux shall be an activated flux (0.2 percent) as specified in IS 9000 (Part 18) : 1981. The test specimen shall not exhibit charring, contamination, softening, or lifting when tested by thermal shock. Lifting is allowable for Class 1 and Class 2 products. The test methods, temperatures, and time shall be as specified in Table 4.

Table 4 Thermal Shock Condition

Class	Test Method of IS 7405 (Part 1) : 1983	Time
1	13.2.3	5 s
2	13.2.3	10 s
3	Under consideration	10 s

7.2.5.1 *Test specimen*

A production board on standard test pattern shall be used as agreed between customer and vendor. Three test specimens, with the solder-resist coating applied and cured as recommended by the manufacturer, shall be evaluated.

7.3 Chemical Tests

7.3.1 *Resistance to Solvents, Fluxes and Soldering*

The cured solder-resist coating shall not exhibit a degradation in surface characteristics, such as surface roughness or webbing, swelling, blistering or colour change when tested according to **12.5** of IS 7405 (Part 1) : 1983. The flux shall be an activated flux (0.25) as specified in IS 9000 (Part 18) : 1981.

7.3.1.1 *Test specimen*

Three printed boards, with the solder-resist coating applied and cured as recommended by the manufacturer, shall be evaluated.

7.3.2 *Solderability*

The solder-resist coating process shall not adversely affect the desired solderability of the printed board, as a result of solder-resist bleeding or other contamination when tested according to **12.2** of IS 7405 (Part 1) : 1983 using activated flux (0.2 percent) as specified in IS 9000 (Part 18) : 1981.

7.3.2.1 *Test specimen*

Three printed boards, with the solder-resist coating applied and cured as recommended by the manufacturer, shall be evaluated.

7.3.3 *Wettability of the Cured Solder-Resist Surface by Soldering Flux*

The degree of allowable dewetting of flux on a cured solder-resist shall be as agreed to between user and board manufacturer. The specimens shall be covered with a flux that is specified as normal for the user. The degree of dewetting shall be assessed after applying the flux in a manner that is normal for the user.

7.3.3.1 *Test specimen*

Three coated copper-clad specimens 250 mm + 5 mm × 250 mm + 5 mm, with the solder-resist coating applied and cured, as recommended by the manufacturer, shall be evaluated.

7.4 Environmental

The production printed board or test specimens shall be cleaned, handled, and stored so that, at the time of coating of solder-resist in preparation for environmental testing, the boards or test specimens shall meet the cleanliness requirements.

7.4.1 *Insulation Resistance*

The solder-resist coating printed board shall have a minimum resistance as specified on the relevant specification when tested according to **10.4.1** of IS 7405 (Part 1) : 1983.

7.4.1.1 *Test specimen*

Three printed boards, with the solder-resist coating applied and cured as recommended by the manufacturer, shall be evaluated. These specimens may also be used for evaluations in **7.4.2** and **7.4.3**.

7.4.2 *Moisture and Insulation Resistance*

The moisture and insulation resistance of the solder-resist coated test board shall be subjected to the conditions of the relevant class and tested according to **10.4.1** of IS 7405 (Part 1) : 1983. The test conditions and minimum requirements for the relevant classes are specified in Table 5.

7.4.2.1 *Test specimen*

Three printed boards, with the solder-resist coating applied and cured as recommended by the manufacturer, shall be evaluated (*see* **7.4.1.1**).

7.4.3 *Electromigration*

Specimens tested in accordance with **7.4.2** shall exhibit no electromigration when examine with approximately 10 × linear magnification. When specified additional specimens shall be tested and examined according to Test Method 3 of Annex A.

7.4.3.1 *Test specimen*

Three printed boards, with the solder-resist coating applied and cured as recommended by the manufacturer, shall be evaluated.

Table 5 Insulation Resistance Requirements

(*Clause* 7.4.2)

Class	Test Condition	Time	Polarizing Voltage (dc) (V)	Minimum Requirement M ohm in Chamber	Minimum Requirement M ohm after Recovery
1	IS 9000 (Part 4) : 1981 Static, $93^{+2\%}_{-3\%}$ RH 40°C ± 2°C	10 Days	100	100	100
2	IS 9000 (Part 4) : 1981 Static, $93^{+2\%}_{-3\%}$ RH 40°C ± 2°C	21 Days	100	100	1 000
3	IS 9000 (Part 4) : 1981 Static, $93^{+2\%}_{-3\%}$ RH 40°C ± 2°C or	56 Days	100	500	5 000
4	IS 9000 (Part 6) : 1978 Cyclic 80 - 96% RH 40°C ± 2°C	10 cyles of 24 hours duration, excluding sub-zero temperature	100	500	5 000

NOTE — Two Methods for Class 3.

7.4.4 *High Temperature Storage*

The solder-resist coated test specimen shall not exhibit blistering, delamination, or cracking of the solder-resist when subjected to the conditions in Table 6.

Table 6 Storage Conditions

Class	Conditions	Time/Days	Temperature
1	—	—	—
2	IS 9000 (Part 3) : 1977	56	100°C
3	IS 9000 (Part 3) : 1977	56	125°C

7.4.4.1 *Test specimen*

Three printed boards, with the solder-resist coating applied and cured as recommended by the manufacturer, shall be evaluated.

7.4.5 *Temperature Cycling*

The solder-resist coated test specimen shall not exhibit blistering, delamination, or cracking when subjected to the conditions in Table 7.

Table 7 Temperature Cycling

Class	Test Method IEC	Cycles	Temperature
1	—	—	—
2	—	—	—
3	IS 9000 (Part 14) : 1978	100	-65 to +125°C

7.4.5.1 *Test Specimen*

Three printed boards, with the solder-resist coating applied and cured as recommended by the manufacturer, shall be evaluated.

8 DIMENSIONS AND TOLERANCES

8.1 Dry Film Solder-Resist

The width of the dry film rolls shall be as ordered. Table 8 gives the width tolerances for standard rolls of dry film solder-resist.

Table 8 Width Tolerances

Width mm	Tolerance mm
Up to 700	-0 +1.0
Over 700	-0 +1.6

The length of the roll of dry film solder-resist shall be as ordered, with a tolerance of ± 5 percent. In any length of roll, there shall be no more than three splices.

Rolls shall be evenly wound on cores of the size and material agreed upon between purchaser and vendor. Cold flowing of resist at ends of rolls shall not exceed 0.4 mm.

8.2 Liquid Solder-Resist

The quantity of the liquid solder-resist shall be as ordered, with a tolerance of ± 5 percent.

9 PACKING

9.1 Dry Film Solder-Resist

Dry film solder-resist rolls shall be individually wrapped with an opaque material. Depending on the size of the rolls being supplied, rolls may be enclosed as pairs, or several pairs of rolls together, in durable cases. All rolls in a single case shall be of the same lot of material. All containers shall comply with applicable carrier rules and regulations.

9.2 Liquid Solder-Resist

The liquid solder-resist shall be supplied in strong, sound and clean containers. Several containers may be supplied in durable cases. All containers in a single case shall be of the same lot of material. All containers shall comply with applicable carrier rules and regulations.

10 STORAGE PROPERTIES

10.1 Solder-resist coating materials, or their components, when stored in their original sealed containers under the specified temperature conditions shall retain specified properties up to the final date for use.

ANNEX A

(*Clauses* 6.3, 7.2.4 *and* 7.4.3)

TEST METHOD

A-1 TEST METHOD 1 — HYDROLYTIC STABILITY

A-1.0 This test method is to determine the resistance of the applied solder-resist coating when exposed to high humidity at a specific temperature and time condition for each class. This test method is to evaluate the quality of the coated printed boards under storage conditions (non-operating).

A-1.1 Apparatus

a) Reagent grade potassium sulfate,

b) Desiccator, 250 mm diameter minimum,

c) Cotton swabs, and

d) Test chamber (oven) capable of maintaining up to 100 ± 2°C.

A-1.2 Procedure

A-1.2.1 *Test Condition*

Temperature as per the relevant specification, RH as resulting from the prescribed saturated salt solution (approximately 90 percent RH).

A-1.2.2 *Preparation*

Prepare a saturated solution of distilled water and potassium sulfate (35 g per 100 cm^3) at temperature of test as indicated in the relevant specification. Pour into desiccator to a level just below the ceramic plate. Crystals of potassium sulfate should remain visible in the saturated solution at the chamber operating temperature.

Clean test specimen thoroughly using the solder-resist supplier's recommended solutions and procedures.

Place test specimen in the desiccator in a vertical position on the ceramic plate (specimens shall not touch one another), seal the desiccator lid with silicone grease and close desiccator.

Place desiccator in test chamber (oven), pre-set at the conditions in accordance with the relevant specification.

A-1.2.3 *Evaluation*

After the required time exposure, remove test specimens and visually examine for chalking, blistering, cracking and general degradation.

Touch the surface of the coating with swab of absorbent cotton and observe for particles of the cotton adhering to the coating.

NOTE — Examination and testing may be done at intervals between the test chamber time requirements, if there is suspicion of an early failure and evaluation time is critical.

A-2 TEST METHOD 2 — HARDNESS TEST

A-2.1 This method is designed to evaluate the hardness of solder resist coated surfaces.

A-2.2 Apparatus

Standard set of hardness pencils from 4B to 6H.

A-2.3 Procedure

Place the solder-resist coated test board on a film horizontal surface. Starting with the hardest pencil, hold pencil firmly against the solder mask at 45° angle. Push pencil away from the operator with uniform downward and forward pressure in an 8-10 mm stroke. Proceed with the next hardest pencil in succession until a pencil is used which will not cut into or gauge the solder mask.

A-2.4 Evaluation

Record the value of the hardest pencil which will neither cut into nor gauge the solder mark.

A-3 TEST METHOD 3 — ELECTROMIGRATION

A-3.0 This test method is to determine the ability of a solder-resist protective coating withstand an environment conducive to causing electromigration.

A.3.1 Apparatus

a) Power supply	Capable of supplying 10 V dc ± 5 percent @ 1 A *max*
b) Test chamber	Capable of maintaining up to 100 ± 2°C
c) Desiccator	250 mm diameter minimum, with openings for connecting wires to pass through while maintaining a hermetic seal
d) Potassium sulfate	Reagent grade potassium sulfate
e) Resistor	10 k ohm
f) Microscope	10 X

A-3.2 Procedure

A-3.2.1 *Test Conditions*

85 ± 2°C, RH as resulting from the prescribed saturated salt solution (approximately 90 percent RH), 7 days.

A-3.2.2 *Specimen Preparation*

For qualification testing, solder single stranded polytetrafluoroethylene (PTTE) insulated wires to each land of non-common conductors. These wires will be used to connect the lands to the bias voltage outside the chamber while the boards are harmetically sealed in the chamber.

Prepare a saturated solution of distilled water and potassium sulfate (approximately 35 g per 100 cm^3) at 85°C. Pour into the desiccator to a level just below the ceramic plate. Crystals of potassium sulfate should remain visible in the saturated solution in the chamber at operating temperature. Place specimens in the chamber in a vertical position, such that they do not touch one another.

Power the pattern with 10 V dc.

A-3.2.3 *Testing*

Test for seven days at the defined conditions.

Examine board under microscope for electromigration or other causes of coating.

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Doc : No. LTD 17 (1284)

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Printed at Printrade, New Delhi, India